**IN THE UNITED STATES**

**PATENT AND TRADEMARK OFFICE**

Appl. No.: 10/551,321
Applicant(s): Karl Thiele
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TC/A.U.: 2800/2834
Examiner: Derek John Rosenau

Atty. Docket: US 030084 US

Title: TWO-DIMENSIONAL (2D) ARRAY CAPABLE OF HARMONIC GENERATION FOR ULTRASOUND IMAGING

# APPEAL BRIEF

Honorable Assistant Commissioner of Patents
P.O. Box 1450
Alexandria, VA 22313-1450

Sir:

In connection with the Notice of Appeal dated July 19, 2007, Applicants provide the following Appeal Brief in the above captioned application.

## TABLE OF CASES

1. **KSR Int'l Co. v. Teleflex Inc., 127 S. Ct. 1727; 82 U.S.P.Q.2D 1385 (2007)**
2. **Graham v. John Deere Co., 383 U.S. 1, 17, 148 USPQ 459, 467 (1966).**
3. **Monroe Auto Equipment Co. v. Heckethorn Mfg. & Supply Co., 332 F.2d 406, 412 (CA6 1964).**
4. **In re Kahn, 441 F.3d 977 (CAFC 2006).**

## 1. Real Party in Interest

The real party in interest as assignee of the entire right and title to the invention described in the present application is Koninklijke Philips N.V. having a principle place of business at Groenewoudseweg 2, Eindhoven, The Netherlands.

## 2. Related Appeals and Interferences

There are no known related appeals or interferences at this time.

## 3. Status of the Claims

Claims 1-78 are pending in the present application. All have been finally rejected and their rejection is hereby appealed. The rejected claims 1-78 on appeal are duplicated in the Appendix.

## 4. Status of Amendments

A final Office Action on the merits was mailed on April 19, 2007. A Response to the Final Office Action was filed on June 15, 2007, traversing the rejections of the final Office Action. A Notice of Appeal was filed on July 19, 2007.

## 5. Summary of the Claimed Subject Matter[1]

In a representative embodiment, an apparatus comprises a two-dimensional (2D) array transducer 50, 98 transmitting ultrasonic energy in tissue at a fundamental frequency and of sufficient power to generate a harmonic of the fundamental frequency in the tissue. (Kindly refer to Figs. 5-8, page 7, line 4- through page 9, line 16, and claim 1.)

In accordance with another representative embodiment, an apparatus comprises a two-dimensional (2D) array transducer 50 comprising a total number of piezoelectric elements of

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1 In the description to follow, citations to variouslaims, reference numerals, drawings and corresponding text in the specification are provided solely to comply with Patent Office Rules.It is emphasized that these reference numerals, drawings and text are representative in nature, and in not any way limiting of the true scope of the claims. It would therefore be improper to import any meaning into any of the claims simply on

which at least 25% are excited to transmit ultrasonic energy in tissue at a fundamental frequency and of sufficient power to generate a harmonic of the fundamental frequency in the tissue. (Kindly refer to Figs. 5-8, page 7, line 4- through page 9, line 16, and claim 19.)

In accordance with another representative embodiment, an apparatus comprises a transducer handle 30 positionable near tissue, the handle external to ultrasound processing equipment producing control signals for ultrasound imaging; at least some transmit beamforming electronics 92 housed in the handle and generating excitation signals in accordance with the control signals; and a two-dimensional (2D) array transducer 98 housed in the handle and, in accordance with the excitations signals, transmitting ultrasonic energy in tissue at a fundamental frequency and of sufficient power to generate a harmonic of the fundamental frequency in the tissue. (Kindly refer to Fig. 8, page 9, lines 4-23 and claim 35.)

In accordance with another representative embodiment, an apparatus comprises electronic processing equipment 96 producing control signals for ultrasound imaging, and a handle external 30 to the electronic processing equipment 96 and positionable near tissue. The apparatus also comprises at least some transmit beamforming electronics 92 housed in the handle. The apparatus also comprises a communication channel (for example cable 34) connecting the electronic processing equipment to the transmit beamforming electronics in the handle so that the transmit beamforming electronics generates excitation signals in accordance with the control signals produced by the electronic processing equipment. The apparatus also includes a two-dimensional (2D) array transducer 98 housed in the handle and, in accordance with the excitation signals, transmitting ultrasonic energy in tissue near which the handle is positioned at a fundamental frequency and of sufficient power to generate a harmonic of the fundamental frequency in the tissue. (Kindly refer to Figs. 5-8, page 7, line 4- through page 9, line 16, lines 4-23 and claim 55.)

In accordance with another embodiment, an apparatus comprises an array transducer 230 having a checkerboard pattern formed by a plurality of elements (T and R in Fig. 11),

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the basis of illustrative language that is provided here only under obligation to satisfy Patent Office rules for maintaining an Appeal.

each element used to either transmit ultrasonic energy at a fundamental frequency or receive a signal generated in tissue by the transmitted ultrasonic energy.
(Kindly refer to Fig. 11, page 11, line 9 through page 12, line 8 and claim 75.)

In accordance with another representative embodiment, an apparatus comprises an array transducer 230 having a checkerboard pattern formed by a total number of elements (T and R in Fig. 11), at least 25% of the total number of elements used to transmit ultrasonic energy at a fundamental frequency, and a plurality of the elements used to receive a signal generated in tissue by the transmitted ultrasonic energy. (Kindly refer to Fig. 11, page 11, line 9 through page 12, line 8 and claim 76.)
An apparatus comprising:

In accordance with another representative embodiments, an array transducer 230 having a checkerboard pattern (T and R in Fig. 11) formed by a total number of elements, at least 25% of the total number of elements connected to high-voltage electronics 52 to transmit ultrasonic energy at a fundamental frequency, and a plurality of the elements connected to low-voltage electronics to receive a signal generated in tissue by the transmitted ultrasonic energy. (Kindly refer to Figs. 6 and 11, page 7, line 25 through page 8, line 4, page11, line 9 through page 12, line 8 and claim 77.)

In accordance with another representative embodiment, an apparatus comprises an array transducer 230 having a checkerboard pattern formed by a plurality of elements (T and R in Fig. 11) in an alternating transmit-receive checkerboard pattern, where transmitting elements transmit ultrasonic energy at a fundamental frequency and receiving elements receive a signal generated in tissue by the transmitted ultrasonic energy. (Kindly refer to Fig. 11, page 11, line 9 through page 12, line 8 and claim 78.)

## 6. Grounds of Rejection to be Reviewed on Appeal

The issues in the present matter are whether:

I. Claims 1,2,8,9,11-13,15,19,25-27, 29,30,32,75,76 and 78 were properly rejected under 35 U.S.C. § 103(a) in view of *Ossmann* (U.S. Patent Publication 20060119223) in view of *Sumanaweera, et al.* (Again, Applicants surmise that and base their remarks on U.S. Patent 6,359,367, not 6,625,367 as stated in the Office Action, is being applied.).;

II. Claims 3-5,14,16-18,20, 21, 31, 33-39,42,43,45-60,63,64,66-74 and 77 were rejected under 35 U.S.C. § 103(a) as being unpatentable in view of *Ossmann* in view of *Sumanaweera, et al.* and *Savord* (U.S. Patent 6,380,766). rejected under 35 U.S.C. § 103(a) in view of *Batten, et al.* further in view of *Nichols, et al.* and further in view of *Pechanek, et al.* (U.S. Patent 5,659,785).

III. Claims 6, 7, 10, 22-24 and 28 were rejected under 35 U.S.C. § 103(a) as being unpatentable in view of *Ossmann* in view of *Sumanaweera, et al.* and *Mequio* (U.S. Patent 4,771,205).

IV. Claims 40, 41, 44, 61, 62 and 65 were rejected under 35 U.S.C. § 103(a) as being unpatentable in view of *Ossmann* in view of *Sumanaweera, et al.*, *Savord* and *Mequio*. For at least the reasons set forth below, it is respectfully submitted that this rejection is improper and should be withdrawn.

**7. Argument**

Applicants respectfully traverse all objections and rejections for at least the reasons set forth herein.

**I. Rejection of claims 1,2,8,9,11-13,15,19,25-27, 29,30,32,75,76 and 78 under 35 U.S.C. § 103(a)**

Claims 1,2,8,9,11-13,15,19,25-27, 29,30,32,75,76 and 78 were rejected under 35 U.S.C. § 103(a) in view of *Ossmann* (U.S. Patent Publication 20060119223) in view of *Sumanaweera, et al.*

At the outset, Applicants rely at least on the following standard of law as it relates to obviousness. Under § 103, the scope and content of the prior art are to be determined; differences between the prior art and the claims at issue are to be ascertained; and the level of ordinary skill in the pertinent art resolved. Against this background the obviousness or nonobviousness of the subject matter is determined. Such secondary considerations as commercial success, long felt but unsolved needs, failure of others, etc., might be utilized to give light to the circumstances surrounding the origin of the subject matter sought to be patented. While the sequence of these questions might be reordered in any particular case, the factors continue to define the inquiry that controls. If a court, or patent examiner, conducts this analysis and concludes the claimed subject matter was obvious, the claim is invalid under § 103. *KSR Int'l Co. v. Teleflex Inc.,* 127 S. Ct. 1727; 82 U.S.P.Q.2D 1385 (2007), citing, in part *Graham v. John Deere Co.*, 383 U.S. 1, 17, 148 USPQ 459, 467 (1966).

The Court in *KSR* continued: "A factfinder should be aware, of course, of the distortion caused by hindsight bias and must be cautious of arguments reliant upon *ex post* reasoning. See *Graham*, 383 U.S., at 36, 86 S. Ct. 684, 15 L. Ed. 2d 545 (warning against a "temptation to read into the prior art the teachings of the invention in issue" and instructing courts to "'guard against slipping into the use of hindsight'" (quoting *Monroe Auto Equipment Co.* v. *Heckethorn Mfg. & Supply Co.*, 332 F.2d 406, 412 (CA6 1964))). Furthermore, rejections on obviousness grounds cannot be sustained by mere conclusory statements; instead there must be some articulated reasoning with some rational underpinning to support the legal conclusion of obviousness. *In re Kahn, 441 F.3d 977* (CAFC 2006)

<u>Claims 1, 19 and 55</u>

Claim 1 is drawn to an apparatus and features, inter alia:

*"... transmitting ultrasonic energy in tissue at a fundamental frequency and of sufficient power to generate a harmonic of the fundamental frequency in the tissue."*

Each of independent claims 19, 35, 55 and 75-78 includes a similar feature.

The Office Action states: "Ossmann discloses an apparatus (Fig. 4) comprising: a two-dimensional array transducer (item 402) transmitting ultrasonic energy in tissue at a fundamental frequency." The Office Action then concedes that the reference fails to disclose that the "...transmitted ultrasonic frequency is transmitted with sufficient power to generate a harmonic of the fundamental frequency..." and turns to secondary references in an attempt to cure this deficiency.

At the outset, Applicants again note that claim 1 differs from its characterization in the Office Action. Particularly, the second quoted portion of the Office Action differs from that which is claimed.

Furthermore, Applicants respectfully submit that the Office Action fails to comply with MPEP § 706. To wit, this section of the MPEP states, inter alia:

"The goal of examination is to clearly articulate any rejection early in the prosecution process so that the applicant has the opportunity to provide evidence of patentability and otherwise reply completely at the earliest opportunity."

In applying *Ossmann* in the rejection of claim 1, the Office Action cites a drawing figure (Fig. 4) and one reference character (402). There is no clear recitation of paragraphs or other reference characters of the reference that are the basis of the rejection. Within the over twelve paragraphs (approximately three columns) of *Ossmann* that relate to Fig. 4, the Examiner does not specifically cite where *Ossmann* discloses *transmitting ultrasonic energy in tissue at a fundamental frequency*. Accordingly, Applicants are left to speculate how the applied reference may be germane to the rejection of claim 1. Clearly, this is improper and deprives Applicants from providing a complete response in support of patentability. Thus, Applicants respectfully request that the present Office Action be withdrawn. Moreover, if

another Office Action is provided to Applicants rejecting one or more of the claims, Applicants submit that any subsequent Office Action cannot properly be made final.

The above notwithstanding, Applicants submit that the reference to *Ossmann* does not disclose *transmitting ultrasonic energy in tissue at a fundamental frequency. Ossmann* relates to acoustic imaging systems and includes, inter alia, a protective cover configured to mate with a transducer body. A word search of the reference does not reveal the disclosure of a fundamental frequency or fundamental mode of ultrasonic energy. Reference is made in paragraph [0050] to an imaging system 204 with a beamformer 304 that sets the transmit frequency, $f_0$, and magnitude of various transmit signals. However, there is no teaching or suggestion that the transmit frequency is a fundamental frequency as is specifically claimed.

In the Final Office Action, the Examiner alleged that propagation of the fundamental frequency in tissue was disclosed. In particular, in the Response to Arguments, the Examiner alleges that the transmitted frequency is fo, which is the notation for a fundamental frequency. While Applicants are aware that in certain contexts the fundamental eigenmode may be denoted with a zero subscript, there is absolutely no basis provided by the teachings of *Ossmann* that the transmit frequency is a fundamental frequency. Just as likely (if not more likely given the fact that the transmit frequency in *Ossmann* is described in connection with a transmit beamformer), the nomenclature fo may refer to the **output frequency**. Regardless, Applicants respectfully submit that inferences and conclusions based on possibilities and even probabilities cannot be used in the determination of patentability. So, Applicants maintain that because the reference to *Ossmann* fails to disclose the *transmitting ultrasonic energy in tissue at a fundamental frequency* as alleged in the Office Action, a proper *prima facie* case of obviousness has not been established.

In the Advisory Action the Examiner expands the term fundamental frequency to include in essence all frequencies. In particular, the Examiner states:

"The claim language requires that ultrasonic energy be transmitted in tissue at a fundamental frequency of sufficient power to generate a harmonic of the fundamental

frequency in the tissue. With this claim language, the fundamental frequency can be any frequency. The harmonic simply must be an integer multiple of this fundamental frequency."

Applicants agree with the definition of a harmonic, but strongly disagree with the allegation that the fundamental can be any frequency. By definition, solutions to equations will render an eigenmode, or characteristic mode, which has a frequency often referred to as the fundamental or fundamental mode. So, it is wholly incorrect that any frequency can be the fundamental frequency as claimed. A mathematical explanation would be that only one mode (and thus frequency) can be the fundamental, thus not all frequencies can be the fundamental.

Furthermore, even if properly combinable with *Ossmann, Sumanaweera, et al.* does not cure the deficiency that the ultrasonic energy is transmitted into *tissue at a fundamental frequency and* ***of sufficient power to generate a harmonic of the fundamental frequency in the tissue***. Applicants have reviewed the portions of *Sumanaweera, et al.* relied upon by the Examiner and find no description of the energy of transmission.

Furthermore, the Examiner does not even address this particular feature of the claim. To wit, the Office Action states:

> Sumanaweera et al. teaches an ultrasonic transducer array in which the transmitted frequency is the fundamental frequency, which excites a harmonic frequency of the fundamental frequency in the tissue (column 8, line 6 through column 9, line 5).
>
> At the time of invention, it would have been obvious to a person of ordinary skill in the art to combine the Harmonic frequency response of Sumanaweera et al. with the transducer array of Ossmann for the benefit of eliminating the need for additional contrast agent in creating the ultrasonic image (column 9, lines 48-51).

Therefore, because the Office Action fails to address this feature of the claim, a proper rejection has not been made.

The Advisory Action does attempt to address Applicants' previous response to this deficiency in the Office Action. Notably, the Office Action alleges in essence that because harmonics are found due to non-linear affects, the reference necessarily discloses the noted feature of the sufficiency of the energy.

Applicants have reviewed this portion of the applied art and respectfully submit that while the reference notes the non-linear affects of the generation of harmonics, the basis for their generation is not elaborated upon, other than the indication that this is a result of tissue characteristics. By contrast and with specific purpose claim 1 features the need for a particular degree of energy in order to excite harmonic generation in the tissue.

In summary, the primary reference to *Ossmann* fails to disclose the *transmitting ultrasonic energy in tissue at a fundamental frequency* as the Office Action alleges. Based on this factor alone, Applicants submit that a *prima facie* case of obviousness has not been made. Moreover, the secondary reference to *Sumanaweera, et al.* fails to disclose the featured ***power to generate a harmonic of the fundamental frequency in the tissue.***

For at least the reasons set forth above, Applicants respectfully submit that a *prima facie* case of obviousness has not been made as to claims 1, 19 and 55. As such, these claims are patentable over the applied art. Moreover, claims 2-18, claims 20-34 and 56-74, which depend from claims 1, 19 and 55, respectively, are also patentable over the applied art for at least the same reasons.

Claims 75, 76 and 78

Claim 75 is drawn to an array transducer comprising:

*a checkerboard pattern formed by a plurality of elements, each element used to either transmit ultrasonic energy at a fundamental frequency or receive a signal generated in tissue by the transmitted ultrasonic energy.*

Claims 76 and 78 include a similar feature.

The Examiner directs Applicants to the treatment of claims 15 and 32 in the rejection of claims 75, 76 and 78.[2] To wit,

> Therefore, although neither Ossmann nor Sumanaweera et al. discloses the alternating checkerboard pattern of the transmit and receive elements, it would have been obvious to a person of ordinary skill in the art to rearrange the transmit and receive elements of Ossmann and Sumanaweera et al. into any desired pattern, including an alternating checkerboard pattern. Additionally, it ahs long been held that it would be obvious to a person of ordinary skill in the art to optimize a device, where the modifications require only routine experimentation (*In re Aller* 105 USPQ 233). Therefore, it would have been obvious to a person of ordinary skill in the art to rearrange the transmit and receive elements of Ossmann and Sumanaweera et al. into different patterns, including an alternating checkerboard pattern.

Applicants respectfully disagree and submit that the combination of references is improper. The Office Action concedes that although neither reference discloses the checkerboard pattern, it would still be obvious to combine *Ossmann* and *Sumanaweera, et al.* to arrive at the claimed pattern. Respectfully, this logic is flawed, for if one reference does not teach a feature of a claim, and another reference does not teach the feature either, then their combination, proper or not, cannot result in the feature.

Next, the Examiner relegates the checkerboard to that of routine experimentation in view of the teachings of the applied art. However, there is no basis provided for this. Notably, *Ossmann* teaches a matrix of transducer elements; and *Sumanaweera, et al.* teach a spiral transducer array. Without clear substantiation or evidence as to support the allegation, the Examiner concludes that it is merely an issue of routine experimentation to begin with either of these references to arrive at the claimed *checkerboard pattern formed by a plurality of elements*. Respectfully, Applicants submit that this rejection on obviousness grounds is

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2 Applicants disagree with the assertions that certain claims have the same subject matter as others. (Kindly see

based merely on conclusory statements rather than an articulated reasoning with some rational underpinning to support the legal conclusion of obviousness.

For at least the reasons provided, the rejection of claim 75 is improper should be withdrawn.

**II. Rejection of claims 3-5,14,16-18,20, 21, 31, 33-39,42,43,45-60,63,64,66-74 and 77 under 35 U.S.C. § 103(a)**

The rejection of dependent claims 3-5,14,16-18,20, 21, 31, 33, 34, 36-39,42,43,45-60,63,64,66-74 is addressed above and presently. The rejection of claims 35 and 77 are addressed presently.

Claim 35

Claim 35 features, inter alia,

*a two-dimensional (2D) array transducer housed in the handle and, in accordance with the excitations signals, transmitting ultrasonic energy in tissue at a fundamental frequency and of sufficient power to generate a harmonic of the fundamental frequency in the tissue.*

In the rejection, the Examiner applies the same art and reasoning as in the rejection of claims 1 and 55. Accordingly, in the interest of brevity, Applicants choose not to repeat their traversal of the rejection here as the basis is, likewise, the same as provided in support of patentability of claims 1 and 55.

Claim 77

Claim 77 features, inter alia,

***an array transducer having a checkerboard pattern** formed by a total number of elements, at least 25% of the total number of elements connected to high-voltage electronics to transmit ultrasonic energy at a fundamental frequency, and a plurality of the elements*

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for example items 13 and 26 of the Office Action. Applicants maintain that these claims are differentiated.

*connected to low-voltage electronics to receive a signal generated in tissue by the transmitted ultrasonic energy.*

The Office Action directs Applicants to the rejection of other claims in rejecting claim 77 and provides no further basis for the rejection. Applicants have rebutted the application of art to the featured checkerboard pattern of the present rejection. Applicants again do not repeat the details, but rather direct the Examiner to arguments made previously, for instance, supporting the patentability of claim 75.

**III. and IV. Rejection of claims 6, 7, 10, 22-24 and 28 and claims 40, 41, 44, 61, 62 and 65 under 35 U.S.C. § 103(a)**

The noted rejected claims all depend directly or indirectly from an independent claim. The arguments and evidence provided above in support of patentability of their respective independent claims applies to these claims as well.

**8. Conclusion**

In view of the foregoing, applicant(s) respectfully request(s): the withdrawal of all objections and rejections of record; the allowance of all the pending claims; and the holding of the application in condition for allowance.

Respectfully submitted on behalf of:

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## Appendix

## Claims on Appeal

Claims on Appeal:

1. An apparatus comprising:

a two-dimensional (2D) array transducer transmitting ultrasonic energy in tissue at a fundamental frequency and of sufficient power to generate a harmonic of the fundamental frequency in the tissue.

2. An apparatus as in claim 1, wherein the array transducer includes a total number of elements of which at least 25% are excited to transmit the ultrasonic energy.

3. An apparatus as in claim 1, further comprising:

transmit beamforming electronics including a high voltage circuit driving the array transducer to transmit the ultrasonic energy.

4. An apparatus as in claim 1, further comprising:

a high voltage field effect transistor (FET) driving the array transducer to transmit the ultrasonic energy.

5. An apparatus as in claim 1, further comprising:

means for driving the array transducer with a high voltage to transmit the ultrasonic energy.

6. An apparatus as in claim 1, wherein the array transducer includes a plurality of piezoelectric elements forming the array transducer, the apparatus further comprising:

a high impedance backing for the piezoelectric elements.

7. An apparatus as in claim 1, wherein the array transducer includes a plurality of piezoelectric elements forming the array transducer, the apparatus further comprising:

means for providing a high impedance backing for the piezoelectric elements.

8. An apparatus as in claim 1, wherein the array transducer is constructed of materials comprising a single crystal.

9. An apparatus as in claim 1, wherein the array transducer is constructed of a plurality of piezoelectric elements of a single crystal.

10. An apparatus as in claim 1, wherein the array transducer transmits the ultrasound energy with a waveform having a bandwidth BW greater than or equal to 60% of the fundamental frequency, where $BW = (f_B - f_A)$, $f_B$ is a higher frequency than the fundamental frequency at a power level 6 dB lower than at the fundamental frequency, $f_A$ is a lower frequency than the fundamental frequency at a power level 6 dB lower than the fundamental frequency.

11. An apparatus as in claim 1, wherein the array transducer transmits the ultrasonic energy at a sufficient power to generate a second harmonic in the tissue having a maximum power level of less than 15 dB from the maximum power level of the fundamental frequency in the tissue.

12. An apparatus as in claim 1, wherein the array transducer has a checkerboard pattern formed by a plurality of elements, each element used for either transmit or receive.

13. An apparatus as in claim 1, wherein the array transducer has a checkerboard pattern formed by a total number of elements, at least 25% of the total number of elements being used to transmit and a plurality of the elements used to receive.

14. An apparatus as in claim 1, wherein the array transducer has a checkerboard pattern formed by a total number of elements, at least 25% of the total number of elements connected to high-voltage electronics to transmit the ultrasonic energy, and a plurality of the elements connected to low-voltage electronics to receive the generated harmonic.

15. An apparatus as in claim 1, wherein the array transducer is formed by a plurality of elements in an alternating transmit-receive checkerboard pattern.

16. An apparatus as in claim 1, further comprising:

a low-voltage circuit; and

a high-voltage circuit driving the array transducer to transmit the ultrasonic energy, the high voltage circuit including a high-voltage FET, the low-voltage circuit and the high-voltage circuit being monolithically formed on a single substrate.

17. An apparatus as in claim 1, further comprising:

a low-voltage circuit; and

a high-voltage circuit driving the array transducer to transmit the ultrasonic energy, the low-voltage circuit and the high-voltage circuit being formed on a single substrate.

18. An apparatus as in claim 1, further comprising:

means for providing a low-voltage circuit and a high-voltage circuit both formed on the same single substrate, the high-voltage circuit for driving the array transducer to transmit the ultrasonic energy.

19. An apparatus comprising:

a two-dimensional (2D) array transducer comprising a total number of piezoelectric elements of which at least 25% are excited to transmit ultrasonic energy in tissue at a fundamental frequency and of sufficient power to generate a harmonic of the fundamental frequency in the tissue.

20. An apparatus as in claim 19, further comprising:

a high voltage field effect transistor (FET) driving the excited piezoelectric elements to transmit the ultrasonic energy.

21. An apparatus as in claim 19, further comprising:

means for driving the excited piezoelectric elements with a high voltage to transmit the ultrasonic energy.

22. An apparatus as in claim 19, further comprising:

a high impedance backing for the piezoelectric elements.

23. An apparatus as in claim 19, further comprising:

means for providing a high impedance backing for the piezoelectric elements.

24. An apparatus as in claim 20, further comprising:

a high impedance backing for the piezoelectric elements.

25. An apparatus as in claim 19, wherein the piezoelectric elements are of a single crystal.

26. An apparatus as in claim 20, wherein the piezoelectric elements are of a single crystal.

27. An apparatus as in claim 22, wherein the piezoelectric elements are of a single crystal.

28. An apparatus as in claim 19, wherein the array transducer transmits the ultrasound energy with a waveform having a bandwidth BW greater than or equal to 60% of the fundamental frequency, where $BW = (f_B - f_A)$, $f_B$ is a higher frequency than the fundamental frequency at a power level 6 dB lower than at the fundamental frequency, $f_A$ is a lower frequency than the fundamental frequency at a power level 6 dB lower than the fundamental frequency.

29. An apparatus as in claim 19, wherein the array transducer transmits the ultrasonic energy at a sufficient power to generate a second harmonic in the tissue having a maximum power level of less than 15 dB from the maximum power level of the fundamental frequency in the tissue.

30. An apparatus as in claim 19, wherein the piezoelectric elements are in a checkerboard pattern, each piezoelectric element used for either transmit or receive.

31. An apparatus as in claim 19, wherein the excited piezoelectric elements are connected to high-voltage electronics to transmit the ultrasonic energy, and a plurality of the remaining piezoelectric elements are connected to low-voltage electronics to receive the generated harmonic.

32. An apparatus as in claim 19, wherein the piezoelectric elements are arranged in an alternating transmit-receive checkerboard pattern.

33. An apparatus as in claim 19, further comprising:

a low-voltage circuit; and

a high-voltage circuit driving the excited piezoelectric elements to transmit the ultrasonic energy, the low-voltage circuit and the high-voltage circuit being formed on a single substrate.

34. An apparatus as in claim 19, further comprising: means for providing a low-voltage circuit and a high-voltage circuit both formed on the same single substrate, the high-voltage circuit for driving the excited piezoelectric elements to transmit the ultrasonic energy.

35. An apparatus comprising:

a transducer handle positionable near tissue, the handle external to ultrasound processing equipment producing control signals for ultrasound imaging;

at least some transmit beamforming electronics housed in the handle and generating excitation signals in accordance with the control signals; and

a two-dimensional (2D) array transducer housed in the handle and, in accordance with the excitations signals, transmitting ultrasonic energy in tissue at a fundamental frequency and of sufficient power to generate a harmonic of the fundamental frequency in the tissue.

36. An apparatus as in claim 35, wherein the array transducer includes a total number of elements of which at least 25% are excited to transmit the ultrasonic energy.

37. An apparatus as in claim 35, further comprising:

a high voltage circuit driving the array transducer to transmit the ultrasonic energy and housed in the handle.

38. An apparatus as in claim 35, further comprising:

a high voltage field effect transistor (FET) driving the array transducer to transmit the ultrasonic energy and housed in the handle.

39. An apparatus as in claim 35, further comprising:

means for driving the array transducer with a high voltage to transmit the ultrasonic energy, said means being housed in the handle.

40. An apparatus as in claim 35, wherein the array transducer includes a plurality of piezoelectric elements forming the array transducer, the apparatus further comprising:

a high impedance backing for the piezoelectric elements and housed in the handle.

41. An apparatus as in claim 35, wherein the array transducer includes a plurality of piezoelectric elements forming the array transducer, the apparatus further comprising:

means for providing a high impedance backing for the piezoelectric elements, said means being housed in the handle.

42. An apparatus as in claim 35, wherein the array transducer is constructed of materials comprising a single crystal.

43. An apparatus as in claim 35, wherein the array transducer is constructed of a plurality of piezoelectric elements of a single crystal.

44. An apparatus as in claim 35, wherein the array transducer transmits the ultrasound energy with a waveform having a bandwidth BW greater than or equal to 60% of the fundamental frequency, where $BW = (f_B - f_A)$, $f_B$ is a higher frequency than the fundamental frequency at a power level 6 dB lower than at the fundamental frequency, $f_A$ is a lower frequency than the fundamental frequency at a power level 6 dB lower than the fundamental frequency.

45. An apparatus as in claim 35, wherein the array transducer transmits the ultrasonic energy at a sufficient power to generate a second harmonic in the tissue having a maximum power level of less than 15 dB from the maximum power level of the fundamental frequency in the tissue.

46. An apparatus as in claim 35, wherein the array transducer has a checkerboard pattern formed by a plurality of elements, each element used for either transmit or receive.

47. An apparatus as in claim 35, wherein the array transducer has a checkerboard pattern formed by a total number of elements, at least 25% of the total number of elements being used to transmit and a plurality of the elements used to receive.

48. An apparatus as in claim 35, wherein the array transducer has a checkerboard pattern formed by a total number of elements, at least 25% of the total number of elements connected to high-voltage electronics to transmit the ultrasonic energy, and a plurality of the elements connected to low-voltage electronics to receive the generated harmonic.

49. An apparatus as in claim 35, wherein the array transducer is formed by a plurality of elements in an alternating transmit-receive checkerboard pattern.

50. An apparatus as in claim 35, further comprising:

a low-voltage circuit; and

a high-voltage circuit driving the array transducer to transmit the ultrasonic energy, the high voltage circuit including a high-voltage FET, the low-voltage circuit and the high-voltage

circuit being monolithically formed on a single substrate and being housed in the handle.

51. An apparatus as in claim 35, further comprising:

a low-voltage circuit; and

a high-voltage circuit driving the array transducer to transmit the ultrasonic energy, the low-voltage circuit and the high-voltage circuit being formed on a single substrate and being housed in the handle.

52. An apparatus as in claim 35, further comprising:

means for providing a low-voltage circuit and a high-voltage circuit both formed on the same single substrate, the high-voltage circuit for driving the array transducer to transmit the ultrasonic energy, said means being housed in the handle.

53. An apparatus as in claim 35, further comprising:

a communication channel connecting the handle to the ultrasound processing equipment to allow the control signals produced by the electronic processing equipment to be provided to the beamforming electronics in the handle.

54. An apparatus as in claim 53, wherein the communication channel is one of the group consisting of a cable and a wireless communications channel.

55. An apparatus comprising:

electronic processing equipment producing control signals for ultrasound imaging;

a handle external to the electronic processing equipment and positionable near tissue;

at least some transmit beamforming electronics housed in the handle;

a communication channel connecting the electronic processing equipment to the transmit beamforming electronics in the handle so that the transmit beamforming electronics generates excitation signals in accordance with the control signals produced by the electronic processing equipment; and

a two-dimensional (2D) array transducer housed in the handle and, in accordance with the excitation signals, transmitting ultrasonic energy in tissue near which the handle is positioned at a fundamental frequency and of sufficient power to generate a harmonic of the

fundamental frequency in the tissue.

56. An apparatus as in claims 55, wherein the array transducer receives the generated harmonic, the apparatus further comprising:

at least some receive beamforming electronics housed in the handle and processing the received harmonic, the receive beamforming electronics connected to the electronic processing equipment by the communication channel to allow the electronic processing equipment to display an ultrasonic image on a display in accordance with the harmonic processed by the receive beamforming electronics.

57. An apparatus as in claim 55, wherein the array transducer includes a total number of elements of which at least 25% are excited to transmit the ultrasonic energy.

58. An apparatus as in claim 55, further comprising:

a high voltage circuit driving the array transducer to transmit the ultrasonic energy and housed in the handle.

59. An apparatus as in claim 55, further comprising:

a high voltage field effect transistor (FET) driving the array transducer to transmit the ultrasonic energy and housed in the handle.

60. An apparatus as in claim 55, further comprising:

means for driving the array transducer with a high voltage to transmit the ultrasonic energy, said means being housed in the handle.

61. An apparatus as in claim 55, wherein the array transducer includes a plurality of piezoelectric elements forming the array transducer, the apparatus further comprising:

a high impedance backing for the piezoelectric elements and housed in the handle.

62. An apparatus as in claim 55, wherein the array transducer includes a plurality of piezoelectric elements forming the array transducer, the apparatus further comprising:

means for providing a high impedance backing for the piezoelectric elements, said means being housed in the handle.

63. An apparatus as in claim 55, wherein the array transducer is constructed of materials

comprising a single crystal.

64. An apparatus as in claim 55, wherein the array transducer is constructed of a plurality of piezoelectric elements of a single crystal.

65. An apparatus as in claim 55, wherein the array transducer transmits the ultrasound energy with a waveform having a bandwidth BW greater than or equal to 60% of the fundamental frequency, where BW = ($f_B$ - $f_A$), $f_B$ is a higher frequency than the fundamental frequency at a power level 6 dB lower than at the fundamental frequency, $f_A$ is a lower frequency than the fundamental frequency at a power level 6 dB lower than the fundamental frequency.

66. An apparatus as in claim 55, wherein the array transducer transmits the ultrasonic energy at a sufficient power to generate a second harmonic in the tissue having a maximum power level of less than 15 dB from the maximum power level of the fundamental frequency in the tissue.

67. An apparatus as in claim 55, wherein the array transducer has a checkerboard pattern formed by a plurality of elements, each element used for either transmit or receive.

68. An apparatus as in claim 55, wherein the array transducer has a checkerboard pattern formed by a total number of elements, at least 25% of the total number of elements being used to transmit and a plurality of the elements used to receive.

69. An apparatus as in claim 55, wherein the array transducer has a checkerboard pattern formed by a total number of elements, at least 25% of the total number of elements connected to high-voltage electronics in the handle to transmit the ultrasonic energy, and a plurality of the elements connected to low-voltage electronics in the handle to receive the generated harmonic.

70. An apparatus as in claim 55, wherein the array transducer is formed by a plurality of elements in an alternating transmit-receive checkerboard pattern.

71. An apparatus as in claim 55, further comprising:

a low-voltage circuit; and

a high-voltage circuit driving the array transducer to transmit the ultrasonic energy, the high voltage circuit including a high-voltage FET, the low-voltage circuit and the high-voltage circuit being monolithically formed on a single substrate and being housed in the handle.

72. An apparatus as in claim 55, further comprising:

a low-voltage circuit; and

a high-voltage circuit driving the array transducer to transmit the ultrasonic energy, the low-voltage circuit and the high-voltage circuit being formed on a single substrate and being housed in the handle.

73. An apparatus as in claim 55, further comprising:

means for providing a low-voltage circuit and a high-voltage circuit both formed on the same single substrate, the high-voltage circuit for driving the array transducer to transmit the ultrasonic energy, said means being housed in the handle.

74. An apparatus as in claim 55, wherein the communication channel is one of the group consisting of a cable and a wireless communications channel.

75. An apparatus comprising:

an array transducer having a checkerboard pattern formed by a plurality of elements, each element used to either transmit ultrasonic energy at a fundamental frequency or receive a signal generated in tissue by the transmitted ultrasonic energy.

76. An apparatus comprising:

an array transducer having a checkerboard pattern formed by a total number of elements, at least 25% of the total number of elements used to transmit ultrasonic energy at a fundamental frequency, and a plurality of the elements used to receive a signal generated in tissue by the transmitted ultrasonic energy.

77. An apparatus comprising:

an array transducer having a checkerboard pattern formed by a total number of elements, at least 25% of the total number of elements connected to high-voltage electronics to transmit ultrasonic energy at a fundamental frequency, and a plurality of the elements

connected to low-voltage electronics to receive a signal generated in tissue by the transmitted ultrasonic energy.

78. An apparatus comprising:

an array transducer having a checkerboard pattern formed by a plurality of elements in an alternating transmit-receive checkerboard pattern, where transmitting elements transmit ultrasonic energy at a fundamental frequency and receiving elements receive a signal generated in tissue by the transmitted ultrasonic energy.

## Appendix

## Evidence (None)

## Appendix

## Related Proceedings (None)